

Homework 5

PSTAT 131/231

Contents

Elastic Net Tuning

```
pokemon <- read.csv(file = "~/Downloads/homework-5/data/Pokemon.csv")
head(pokemon)
```

```
##      X.              Name Type.1 Type.2 Total HP Attack Defense Sp..Atk
## 1  1      Bulbasaur   Grass Poison   318 45    49    49    65
## 2  2      Ivysaur    Grass Poison   405 60    62    63    80
## 3  3      Venusaur   Grass Poison   525 80    82    83   100
## 4  3 VenusaurMega Venusaur   Grass Poison   625 80   100   123   122
## 5  4      Charmander   Fire          309 39    52    43    60
## 6  5      Charmeleon   Fire          405 58    64    58    80
##      Sp..Def Speed Generation Legendary
## 1      65    45          1      False
## 2      80    60          1      False
## 3     100    80          1      False
## 4     120    80          1      False
## 5      50    65          1      False
## 6      65    80          1      False
```

Exercise 1

Install and load the `janitor` package. Use its `clean_names()` function on the Pokemon data, and save the results to work with for the rest of the assignment. What happened to the data? Why do you think `clean_names()` is useful?

The title for each column heading is fixed to a more understandable title. It is more neatly organized and shows more rows with different name types. I do think ‘`clean_names()`’ is useful to understand more about the data I have since it organizes the data so that it could be read easily.

```
library(janitor)
pokemon <- pokemon %>% clean_names()
```

Exercise 2

Using the entire data set, create a bar chart of the outcome variable, ‘`type_1`’.

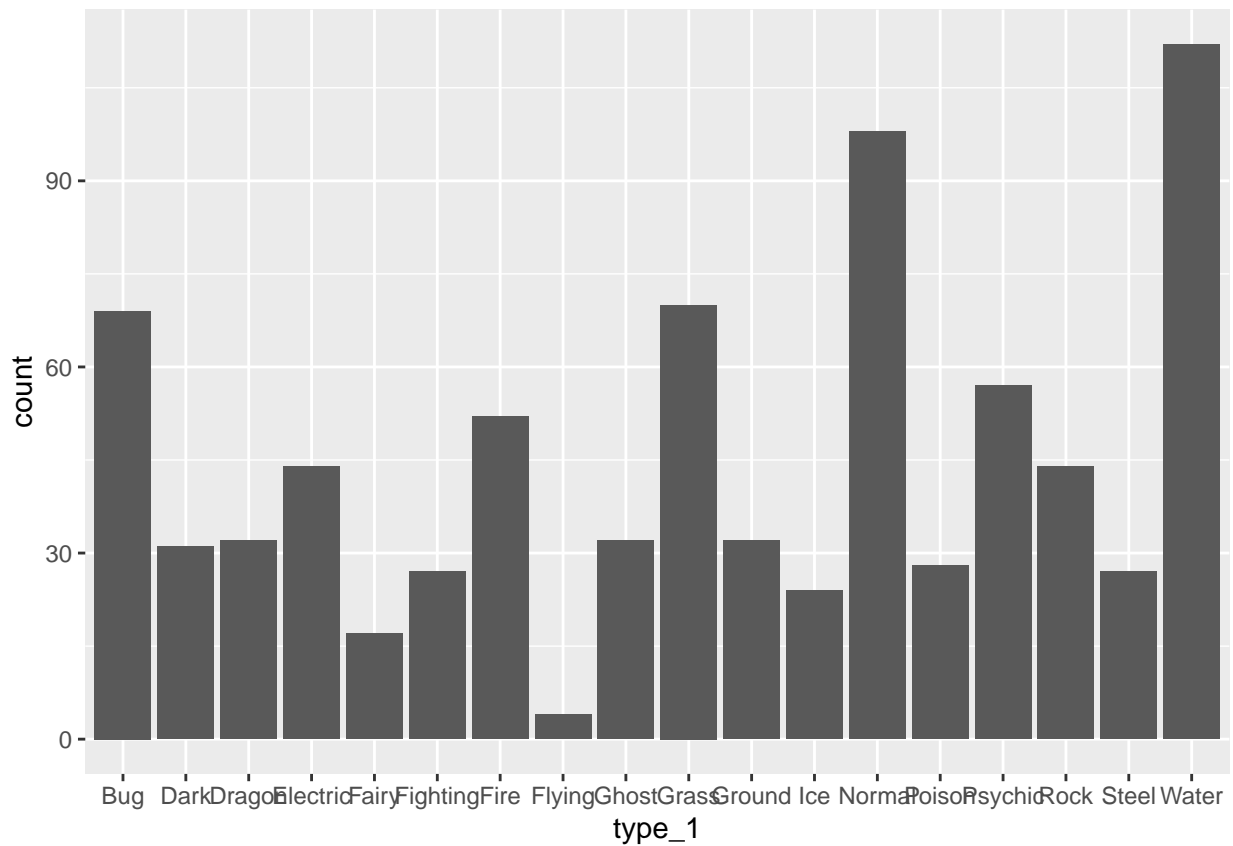
How many classes of the outcome are there? Are there any Pokemon types with very few Pokemon? If so, which ones?

For this assignment, we'll handle the rarer classes by simply filtering them out. Filter the entire data set to contain only Pokemon whose 'type_1' is Bug, Fire, Grass, Normal, Water, or Psychic.

After filtering, convert 'type_1' and 'legendary' to factors.

There are 17 classes of the outcomes here. There is one Pokemon type which is "Flying" with very few Pokemon.

```
library(ggplot2)
# Most basic bar chart
ggplot(pokemon, aes(x = type_1)) +
  geom_bar()
```



```
pokemon_filter <- pokemon[pokemon$type_1 %in% c("Bug", "Fire", "Grass", "Normal", "Water", "Psychic"),]
pokemon_filter
```

##	x	name	type_1	type_2	total	hp	attack	defense
## 1	1	Bulbasaur	Grass	Poison	318	45	49	49
## 2	2	Ivysaur	Grass	Poison	405	60	62	63
## 3	3	Venusaur	Grass	Poison	525	80	82	83
## 4	3	VenusaurMega Venusaur	Grass	Poison	625	80	100	123
## 5	4	Charmander	Fire		309	39	52	43
## 6	5	Charmeleon	Fire		405	58	64	58
## 7	6	Charizard	Fire	Flying	534	78	84	78
## 8	6	CharizardMega Charizard X	Fire	Dragon	634	78	130	111

## 9	6	CharizardMega	Charizard Y	Fire	Flying	634	78	104	78
## 10	7		Squirtle	Water		314	44	48	65
## 11	8		Wartortle	Water		405	59	63	80
## 12	9		Blastoise	Water		530	79	83	100
## 13	9	BlastoiseMega	Blastoise	Water		630	79	103	120
## 14	10		Caterpie	Bug		195	45	30	35
## 15	11		Metapod	Bug		205	50	20	55
## 16	12		Butterfree	Bug	Flying	395	60	45	50
## 17	13		Weedle	Bug	Poison	195	40	35	30
## 18	14		Kakuna	Bug	Poison	205	45	25	50
## 19	15		Beedrill	Bug	Poison	395	65	90	40
## 20	15	BeedrillMega	Beedrill	Bug	Poison	495	65	150	40
## 21	16		Pidgey	Normal	Flying	251	40	45	40
## 22	17		Pidgeotto	Normal	Flying	349	63	60	55
## 23	18		Pidgeot	Normal	Flying	479	83	80	75
## 24	18	PidgeotMega	Pidgeot	Normal	Flying	579	83	80	80
## 25	19		Rattata	Normal		253	30	56	35
## 26	20		Raticate	Normal		413	55	81	60
## 27	21		Spearow	Normal	Flying	262	40	60	30
## 28	22		Fearow	Normal	Flying	442	65	90	65
## 43	37		Vulpix	Fire		299	38	41	40
## 44	38		Ninetales	Fire		505	73	76	75
## 45	39		Jigglypuff	Normal	Fairy	270	115	45	20
## 46	40		Wigglytuff	Normal	Fairy	435	140	70	45
## 49	43		Oddish	Grass	Poison	320	45	50	55
## 50	44		Gloom	Grass	Poison	395	60	65	70
## 51	45		Vileplume	Grass	Poison	490	75	80	85
## 52	46		Paras	Bug	Grass	285	35	70	55
## 53	47		Parasect	Bug	Grass	405	60	95	80
## 54	48		Venonat	Bug	Poison	305	60	55	50
## 55	49		Venomoth	Bug	Poison	450	70	65	60
## 58	52		Meowth	Normal		290	40	45	35
## 59	53		Persian	Normal		440	65	70	60
## 60	54		Psyduck	Water		320	50	52	48
## 61	55		Golduck	Water		500	80	82	78
## 64	58		Growlithe	Fire		350	55	70	45
## 65	59		Arcanine	Fire		555	90	110	80
## 66	60		Poliwag	Water		300	40	50	40
## 67	61		Poliwhirl	Water		385	65	65	65
## 68	62		Poliwrath	Water	Fighting	510	90	95	95
## 69	63		Abra	Psychic		310	25	20	15
## 70	64		Kadabra	Psychic		400	40	35	30
## 71	65		Alakazam	Psychic		500	55	50	45
## 72	65	AlakazamMega	Alakazam	Psychic		590	55	50	65
## 76	69		Bellsprout	Grass	Poison	300	50	75	35
## 77	70		Weepinbell	Grass	Poison	390	65	90	50
## 78	71		Victreebel	Grass	Poison	490	80	105	65
## 79	72		Tentacool	Water	Poison	335	40	40	35
## 80	73		Tentacruel	Water	Poison	515	80	70	65
## 84	77		Ponyta	Fire		410	50	85	55
## 85	78		Rapidash	Fire		500	65	100	70
## 86	79		Slowpoke	Water	Psychic	315	90	65	65
## 87	80		Slowbro	Water	Psychic	490	95	75	110
## 88	80	SlowbroMega	Slowbro	Water	Psychic	590	95	75	180

##	91	83	Farfetch'd	Normal	Flying	352	52	65	55
##	92	84	Doduo	Normal	Flying	310	35	85	45
##	93	85	Dodrio	Normal	Flying	460	60	110	70
##	94	86	Seel	Water		325	65	45	55
##	95	87	Dewgong	Water	Ice	475	90	70	80
##	98	90	Shellder	Water		305	30	65	100
##	99	91	Cloyster	Water	Ice	525	50	95	180
##	105	96	Drowzee	Psychic		328	60	48	45
##	106	97	Hypno	Psychic		483	85	73	70
##	107	98	Krabby	Water		325	30	105	90
##	108	99	Kingler	Water		475	55	130	115
##	111	102	Exeggcute	Grass	Psychic	325	60	40	80
##	112	103	Exeggutor	Grass	Psychic	520	95	95	85
##	117	108	Lickitung	Normal		385	90	55	75
##	122	113	Chansey	Normal		450	250	5	5
##	123	114	Tangela	Grass		435	65	55	115
##	124	115	Kangaskhan	Normal		490	105	95	80
##	125	115	KangaskhanMega Kangaskhan	Normal		590	105	125	100
##	126	116	Horsea	Water		295	30	40	70
##	127	117	Seadra	Water		440	55	65	95
##	128	118	Goldeen	Water		320	45	67	60
##	129	119	Seaking	Water		450	80	92	65
##	130	120	Staryu	Water		340	30	45	55
##	131	121	Starmie	Water	Psychic	520	60	75	85
##	132	122	Mr. Mime	Psychic	Fairy	460	40	45	65
##	133	123	Scyther	Bug	Flying	500	70	110	80
##	136	126	Magmar	Fire		495	65	95	57
##	137	127	Pinsir	Bug		500	65	125	100
##	138	127	PinsirMega Pinsir	Bug	Flying	600	65	155	120
##	139	128	Tauros	Normal		490	75	100	95
##	140	129	Magikarp	Water		200	20	10	55
##	141	130	Gyarados	Water	Flying	540	95	125	79
##	142	130	GyaradosMega Gyarados	Water	Dark	640	95	155	109
##	143	131	Lapras	Water	Ice	535	130	85	80
##	144	132	Ditto	Normal		288	48	48	48
##	145	133	Eevee	Normal		325	55	55	50
##	146	134	Vaporeon	Water		525	130	65	60
##	148	136	Flareon	Fire		525	65	130	60
##	149	137	Porygon	Normal		395	65	60	70
##	156	143	Snorlax	Normal		540	160	110	65
##	159	146	Moltres	Fire	Flying	580	90	100	90
##	163	150	Mewtwo	Psychic		680	106	110	90
##	164	150	MewtwoMega Mewtwo X	Psychic	Fighting	780	106	190	100
##	165	150	MewtwoMega Mewtwo Y	Psychic		780	106	150	70
##	166	151	Mew	Psychic		600	100	100	100
##	167	152	Chikorita	Grass		318	45	49	65
##	168	153	Bayleef	Grass		405	60	62	80
##	169	154	Meganium	Grass		525	80	82	100
##	170	155	Cyndaquil	Fire		309	39	52	43
##	171	156	Quilava	Fire		405	58	64	58
##	172	157	Typhlosion	Fire		534	78	84	78
##	173	158	Totodile	Water		314	50	65	64
##	174	159	Croconaw	Water		405	65	80	80
##	175	160	Feraligatr	Water		530	85	105	100

##	176	161	Sentret	Normal		215	35	46	34
##	177	162	Furret	Normal		415	85	76	64
##	178	163	Hoothoot	Normal	Flying	262	60	30	30
##	179	164	Noctowl	Normal	Flying	442	100	50	50
##	180	165	Ledyba	Bug	Flying	265	40	20	30
##	181	166	Ledian	Bug	Flying	390	55	35	50
##	182	167	Spinarak	Bug	Poison	250	40	60	40
##	183	168	Ariados	Bug	Poison	390	70	90	70
##	185	170	Chinchou	Water	Electric	330	75	38	38
##	186	171	Lanturn	Water	Electric	460	125	58	58
##	189	174	Igglybuff	Normal	Fairy	210	90	30	15
##	192	177	Natu	Psychic	Flying	320	40	50	45
##	193	178	Xatu	Psychic	Flying	470	65	75	70
##	198	182	Bellossom	Grass		490	75	80	95
##	199	183	Marill	Water	Fairy	250	70	20	50
##	200	184	Azumarill	Water	Fairy	420	100	50	80
##	202	186	Politoed	Water		500	90	75	75
##	203	187	Hoppip	Grass	Flying	250	35	35	40
##	204	188	Skiploom	Grass	Flying	340	55	45	50
##	205	189	Jumpluff	Grass	Flying	460	75	55	70
##	206	190	Aipom	Normal		360	55	70	55
##	207	191	Sunkern	Grass		180	30	30	30
##	208	192	Sunflora	Grass		425	75	75	55
##	209	193	Yanma	Bug	Flying	390	65	65	45
##	210	194	Wooper	Water	Ground	210	55	45	45
##	211	195	Quagsire	Water	Ground	430	95	85	85
##	212	196	Espeon	Psychic		525	65	65	60
##	215	199	Slowking	Water	Psychic	490	95	75	80
##	217	201	Unown	Psychic		336	48	72	48
##	218	202	Wobbuffet	Psychic		405	190	33	58
##	219	203	Girafarig	Normal	Psychic	455	70	80	65
##	220	204	Pineco	Bug		290	50	65	90
##	221	205	Forretress	Bug	Steel	465	75	90	140
##	222	206	Dunsparce	Normal		415	100	70	70
##	228	211	Qwilfish	Water	Poison	430	65	95	75
##	229	212	Scizor	Bug	Steel	500	70	130	100
##	230	212	ScizorMega Scizor	Bug	Steel	600	70	150	140
##	231	213	Shuckle	Bug	Rock	505	20	10	230
##	232	214	Heracross	Bug	Fighting	500	80	125	75
##	233	214	HeracrossMega Heracross	Bug	Fighting	600	80	185	115
##	235	216	Teddiursa	Normal		330	60	80	50
##	236	217	Ursaring	Normal		500	90	130	75
##	237	218	Slugma	Fire		250	40	40	40
##	238	219	Magcargo	Fire	Rock	410	50	50	120
##	241	222	Corsola	Water	Rock	380	55	55	85
##	242	223	Remoraid	Water		300	35	65	35
##	243	224	Octillery	Water		480	75	105	75
##	245	226	Mantine	Water	Flying	465	65	40	70
##	250	230	Kingdra	Water	Dragon	540	75	95	95
##	253	233	Porygon2	Normal		515	85	80	90
##	254	234	Stantler	Normal		465	73	95	62
##	255	235	Smeargle	Normal		250	55	20	35
##	260	240	Magby	Fire		365	45	75	37
##	261	241	Miltank	Normal		490	95	80	105

##	262	242	Blissey	Normal		540	255	10	10
##	264	244	Entei	Fire		580	115	115	85
##	265	245	Suicune	Water		580	100	75	115
##	270	249	Lugia	Psychic	Flying	680	106	90	130
##	271	250	Ho-oh	Fire	Flying	680	106	130	90
##	272	251	Celebi	Psychic	Grass	600	100	100	100
##	273	252	Treecko	Grass		310	40	45	35
##	274	253	Grovyle	Grass		405	50	65	45
##	275	254	Sceptile	Grass		530	70	85	65
##	276	254	SceptileMega	Sceptile	Grass Dragon	630	70	110	75
##	277	255	Torchic	Fire		310	45	60	40
##	278	256	Combusken	Fire	Fighting	405	60	85	60
##	279	257	Blaziken	Fire	Fighting	530	80	120	70
##	280	257	BlazikenMega	Blaziken	Fire Fighting	630	80	160	80
##	281	258	Mudkip	Water		310	50	70	50
##	282	259	Marshtomp	Water	Ground	405	70	85	70
##	283	260	Swampert	Water	Ground	535	100	110	90
##	284	260	SwampertMega	Swampert	Water Ground	635	100	150	110
##	287	263	Zigzagoon	Normal		240	38	30	41
##	288	264	Linoone	Normal		420	78	70	61
##	289	265	Wurmple	Bug		195	45	45	35
##	290	266	Silcoon	Bug		205	50	35	55
##	291	267	Beautifly	Bug	Flying	395	60	70	50
##	292	268	Cascoon	Bug		205	50	35	55
##	293	269	Dustox	Bug	Poison	385	60	50	70
##	294	270	Lotad	Water	Grass	220	40	30	30
##	295	271	Lombre	Water	Grass	340	60	50	50
##	296	272	Ludicolo	Water	Grass	480	80	70	70
##	297	273	Seedot	Grass		220	40	40	50
##	298	274	Nuzleaf	Grass	Dark	340	70	70	40
##	299	275	Shiftry	Grass	Dark	480	90	100	60
##	300	276	Tailow	Normal	Flying	270	40	55	30
##	301	277	Swellow	Normal	Flying	430	60	85	60
##	302	278	Wingull	Water	Flying	270	40	30	30
##	303	279	Pelipper	Water	Flying	430	60	50	100
##	304	280	Ralts	Psychic	Fairy	198	28	25	25
##	305	281	Kirlia	Psychic	Fairy	278	38	35	35
##	306	282	Gardevoir	Psychic	Fairy	518	68	65	65
##	307	282	GardevoirMega	Gardevoir	Psychic Fairy	618	68	85	65
##	308	283	Surskit	Bug	Water	269	40	30	32
##	309	284	Masquerain	Bug	Flying	414	70	60	62
##	310	285	Shroomish	Grass		295	60	40	60
##	311	286	Breloom	Grass	Fighting	460	60	130	80
##	312	287	Slakoth	Normal		280	60	60	60
##	313	288	Vigoroth	Normal		440	80	80	80
##	314	289	Slaking	Normal		670	150	160	100
##	315	290	Nincada	Bug	Ground	266	31	45	90
##	316	291	Ninjask	Bug	Flying	456	61	90	45
##	317	292	Shedinja	Bug	Ghost	236	1	90	45
##	318	293	Whismur	Normal		240	64	51	23
##	319	294	Loudred	Normal		360	84	71	43
##	320	295	Exploud	Normal		490	104	91	63
##	323	298	Azurill	Normal	Fairy	190	50	20	40
##	325	300	Skitty	Normal		260	50	45	45

##	326	301	Delcatty	Normal		380	70	65	65
##	343	313	Volbeat	Bug		400	65	73	55
##	344	314	Illumise	Bug		400	65	47	55
##	345	315	Roselia	Grass	Poison	400	50	60	45
##	348	318	Carvanha	Water	Dark	305	45	90	20
##	349	319	Sharpedo	Water	Dark	460	70	120	40
##	350	319	SharpedoMega Sharpedo	Water	Dark	560	70	140	70
##	351	320	Wailmer	Water		400	130	70	35
##	352	321	Wailord	Water		500	170	90	45
##	353	322	Numel	Fire	Ground	305	60	60	40
##	354	323	Camerupt	Fire	Ground	460	70	100	70
##	355	323	CameruptMega Camerupt	Fire	Ground	560	70	120	100
##	356	324	Torkoal	Fire		470	70	85	140
##	357	325	Spoink	Psychic		330	60	25	35
##	358	326	Grumpig	Psychic		470	80	45	65
##	359	327	Spinda	Normal		360	60	60	60
##	363	331	Cacnea	Grass		335	50	85	40
##	364	332	Cacturne	Grass	Dark	475	70	115	60
##	365	333	Swablu	Normal	Flying	310	45	40	60
##	368	335	Zangoose	Normal		458	73	115	60
##	372	339	Barboach	Water	Ground	288	50	48	43
##	373	340	Whiscash	Water	Ground	468	110	78	73
##	374	341	Corphish	Water		308	43	80	65
##	375	342	Crawdaunt	Water	Dark	468	63	120	85
##	382	349	Feebas	Water		200	20	15	20
##	383	350	Milotic	Water		540	95	60	79
##	384	351	Castform	Normal		420	70	70	70
##	385	352	Kecleon	Normal		440	60	90	70
##	391	357	Tropius	Grass	Flying	460	99	68	83
##	392	358	Chimecho	Psychic		425	65	50	70
##	395	360	Wynaut	Psychic		260	95	23	48
##	402	366	Clamperl	Water		345	35	64	85
##	403	367	Huntail	Water		485	55	104	105
##	404	368	Gorebyss	Water		485	55	84	105
##	405	369	Relicanth	Water	Rock	485	100	90	130
##	406	370	Luvdisc	Water		330	43	30	55
##	422	382	Kyogre	Water		670	100	100	90
##	423	382	KyogrePrimal Kyogre	Water		770	100	150	90
##	429	386	DeoxysNormal Forme	Psychic		600	50	150	50
##	430	386	DeoxysAttack Forme	Psychic		600	50	180	20
##	431	386	DeoxysDefense Forme	Psychic		600	50	70	160
##	432	386	DeoxysSpeed Forme	Psychic		600	50	95	90
##	433	387	Turtwig	Grass		318	55	68	64
##	434	388	Grotle	Grass		405	75	89	85
##	435	389	Torterra	Grass	Ground	525	95	109	105
##	436	390	Chimchar	Fire		309	44	58	44
##	437	391	Monferno	Fire	Fighting	405	64	78	52
##	438	392	Infernape	Fire	Fighting	534	76	104	71
##	439	393	Piplup	Water		314	53	51	53
##	440	394	Prinplup	Water		405	64	66	68
##	441	395	Empoleon	Water	Steel	530	84	86	88
##	442	396	Starly	Normal	Flying	245	40	55	30
##	443	397	Staravia	Normal	Flying	340	55	75	50
##	444	398	Staraptor	Normal	Flying	485	85	120	70

##	445	399	Bidoof	Normal		250	59	45	40	
##	446	400	Bibarel	Normal	Water	410	79	85	60	
##	447	401	Kricketot	Bug		194	37	25	41	
##	448	402	Kricketune	Bug		384	77	85	51	
##	452	406	Budew	Grass	Poison	280	40	30	35	
##	453	407	Roserade	Grass	Poison	515	60	70	65	
##	458	412	Burmy	Bug		224	40	29	45	
##	459	413	WormadamPlant	Cloak	Bug	Grass	424	60	59	85
##	460	413	WormadamSandy	Cloak	Bug	Ground	424	60	79	105
##	461	413	WormadamTrash	Cloak	Bug	Steel	424	60	69	95
##	462	414	Mothim	Bug	Flying	424	70	94	50	
##	463	415	Combee	Bug	Flying	244	30	30	42	
##	464	416	Vespiquen	Bug	Flying	474	70	80	102	
##	466	418	Buizel	Water		330	55	65	35	
##	467	419	Floatzel	Water		495	85	105	55	
##	468	420	Cherubi	Grass		275	45	35	45	
##	469	421	Cherrim	Grass		450	70	60	70	
##	470	422	Shellos	Water		325	76	48	48	
##	471	423	Gastrodon	Water	Ground	475	111	83	68	
##	472	424	Ambipom	Normal		482	75	100	66	
##	475	427	Buneary	Normal		350	55	66	44	
##	476	428	Lopunny	Normal		480	65	76	84	
##	477	428	LopunnyMega	Lopunny	Normal	Fighting	580	65	136	94
##	480	431	Glameow	Normal		310	49	55	42	
##	481	432	Purugly	Normal		452	71	82	64	
##	482	433	Chingling	Psychic		285	45	30	50	
##	488	439	Mime Jr.	Psychic	Fairy	310	20	25	45	
##	489	440	Happiny	Normal		220	100	5	5	
##	490	441	Chatot	Normal	Flying	411	76	65	45	
##	496	446	Munchlax	Normal		390	135	85	40	
##	506	455	Carnivine	Grass		454	74	100	72	
##	507	456	Finneon	Water		330	49	49	56	
##	508	457	Lumineon	Water		460	69	69	76	
##	509	458	Mantyke	Water	Flying	345	45	20	50	
##	510	459	Snover	Grass	Ice	334	60	62	50	
##	511	460	Abomasnow	Grass	Ice	494	90	92	75	
##	512	460	AbomasnowMega	Abomasnow	Grass	Ice	594	90	132	105
##	515	463	Lickilicky	Normal		515	110	85	95	
##	517	465	Tangrowth	Grass		535	100	100	125	
##	519	467	Magmortar	Fire		540	75	95	67	
##	521	469	Yanmega	Bug	Flying	515	86	76	86	
##	522	470	Leafeon	Grass		525	65	110	130	
##	526	474	Porygon-Z	Normal		535	85	80	70	
##	527	475	Gallade	Psychic	Fighting	518	68	125	65	
##	528	475	GalladeMega	Gallade	Psychic	Fighting	618	68	165	95
##	538	480	Uxie	Psychic		580	75	75	130	
##	539	481	Mesprit	Psychic		580	80	105	105	
##	540	482	Azelf	Psychic		580	75	125	70	
##	542	484	Palkia	Water	Dragon	680	90	120	100	
##	543	485	Heatran	Fire	Steel	600	91	90	106	
##	544	486	Regigigas	Normal		670	110	160	110	
##	547	488	Cresselia	Psychic		600	120	70	120	
##	548	489	Phione	Water		480	80	80	80	
##	549	490	Manaphy	Water		600	100	100	100	

## 551 492	ShayminLand	Forme	Grass		600	100	100	100
## 552 492	ShayminSky	Forme	Grass	Flying	600	100	103	75
## 553 493		Arceus	Normal		720	120	120	120
## 554 494		Victini	Psychic	Fire	600	100	100	100
## 555 495		Snivy	Grass		308	45	45	55
## 556 496		Servine	Grass		413	60	60	75
## 557 497		Serperior	Grass		528	75	75	95
## 558 498		Tepig	Fire		308	65	63	45
## 559 499		Pignite	Fire	Fighting	418	90	93	55
## 560 500		Emboar	Fire	Fighting	528	110	123	65
## 561 501		Oshawott	Water		308	55	55	45
## 562 502		Dewott	Water		413	75	75	60
## 563 503		Samurott	Water		528	95	100	85
## 564 504		Patrat	Normal		255	45	55	39
## 565 505		Watchog	Normal		420	60	85	69
## 566 506		Lillipup	Normal		275	45	60	45
## 567 507		Herdier	Normal		370	65	80	65
## 568 508		Stoutland	Normal		500	85	110	90
## 571 511		Pansage	Grass		316	50	53	48
## 572 512		Simisage	Grass		498	75	98	63
## 573 513		Pansear	Fire		316	50	53	48
## 574 514		Simisear	Fire		498	75	98	63
## 575 515		Panpour	Water		316	50	53	48
## 576 516		Simipour	Water		498	75	98	63
## 577 517		Munna	Psychic		292	76	25	45
## 578 518		Musharna	Psychic		487	116	55	85
## 579 519		Pidove	Normal	Flying	264	50	55	50
## 580 520		Tranquill	Normal	Flying	358	62	77	62
## 581 521		Unfezant	Normal	Flying	488	80	115	80
## 587 527		Woobat	Psychic	Flying	313	55	45	43
## 588 528		Swoobat	Psychic	Flying	425	67	57	55
## 591 531		Audino	Normal		445	103	60	86
## 592 531	AudinoMega	Audino	Normal	Fairy	545	103	60	126
## 596 535		Tympole	Water		294	50	50	40
## 597 536		Palpitoad	Water	Ground	384	75	65	55
## 598 537		Seismitoad	Water	Ground	509	105	95	75
## 601 540		Sewaddle	Bug	Grass	310	45	53	70
## 602 541		Swadloon	Bug	Grass	380	55	63	90
## 603 542		Leavanny	Bug	Grass	500	75	103	80
## 604 543		Venipede	Bug	Poison	260	30	45	59
## 605 544		Whirlipede	Bug	Poison	360	40	55	99
## 606 545		Scolipede	Bug	Poison	485	60	100	89
## 607 546		Cottonee	Grass	Fairy	280	40	27	60
## 608 547		Whimsicott	Grass	Fairy	480	60	67	85
## 609 548		Petilil	Grass		280	45	35	50
## 610 549		Lilligant	Grass		480	70	60	75
## 611 550		Basculin	Water		460	70	92	65
## 615 554		Darumaka	Fire		315	70	90	45
## 616 555	DarmanitanStandard	Mode	Fire		480	105	140	55
## 617 555	DarmanitanZen	Mode	Fire	Psychic	540	105	30	105
## 618 556		Maractus	Grass		461	75	86	67
## 619 557		Dwebble	Bug	Rock	325	50	65	85
## 620 558		Crustle	Bug	Rock	475	70	95	125
## 623 561		Sigilyph	Psychic	Flying	490	72	58	80

## 626 564	Tirtouga	Water	Rock	355	54	78	103
## 627 565	Carracosta	Water	Rock	495	74	108	133
## 634 572	Minccino	Normal		300	55	50	40
## 635 573	Cinccino	Normal		470	75	95	60
## 636 574	Gothita	Psychic		290	45	30	50
## 637 575	Gothorita	Psychic		390	60	45	70
## 638 576	Gothitelle	Psychic		490	70	55	95
## 639 577	Solosis	Psychic		290	45	30	40
## 640 578	Duosion	Psychic		370	65	40	50
## 641 579	Reuniclus	Psychic		490	110	65	75
## 642 580	Ducklett	Water	Flying	305	62	44	50
## 643 581	Swanna	Water	Flying	473	75	87	63
## 647 585	Deerling	Normal	Grass	335	60	60	50
## 648 586	Sawsbuck	Normal	Grass	475	80	100	70
## 650 588	Karrablast	Bug		315	50	75	45
## 651 589	Escavalier	Bug	Steel	495	70	135	105
## 652 590	Foongus	Grass	Poison	294	69	55	45
## 653 591	Amoonguss	Grass	Poison	464	114	85	70
## 654 592	Frillish	Water	Ghost	335	55	40	50
## 655 593	Jellicent	Water	Ghost	480	100	60	70
## 656 594	Alomomola	Water		470	165	75	80
## 657 595	Joltik	Bug	Electric	319	50	47	50
## 658 596	Galvantula	Bug	Electric	472	70	77	60
## 659 597	Ferroseed	Grass	Steel	305	44	50	91
## 660 598	Ferrothorn	Grass	Steel	489	74	94	131
## 667 605	Elgyem	Psychic		335	55	55	55
## 668 606	Beheeyem	Psychic		485	75	75	75
## 678 616	Shelmet	Bug		305	50	40	85
## 679 617	Accelgor	Bug		495	80	70	40
## 688 626	Bouffalant	Normal		490	95	110	95
## 689 627	Rufflet	Normal	Flying	350	70	83	50
## 690 628	Braviary	Normal	Flying	510	100	123	75
## 693 631	Heatmor	Fire		484	85	97	66
## 694 632	Durant	Bug	Steel	484	58	109	112
## 698 636	Larvesta	Bug	Fire	360	55	85	55
## 699 637	Volcarona	Bug	Fire	550	85	60	65
## 702 640	Virizion	Grass	Fighting	580	91	90	72
## 714 647	KeldeoOrdinary Forme	Water	Fighting	580	91	72	90
## 715 647	KeldeoResolute Forme	Water	Fighting	580	91	72	90
## 716 648	MeloettaAria Forme	Normal	Psychic	600	100	77	77
## 717 648	MeloettaPirouette Forme	Normal	Fighting	600	100	128	90
## 718 649	Genesect	Bug	Steel	600	71	120	95
## 719 650	Chespin	Grass		313	56	61	65
## 720 651	Quilladin	Grass		405	61	78	95
## 721 652	Chesnaught	Grass	Fighting	530	88	107	122
## 722 653	Fennekin	Fire		307	40	45	40
## 723 654	Braixen	Fire		409	59	59	58
## 724 655	Delphox	Fire	Psychic	534	75	69	72
## 725 656	Froakie	Water		314	41	56	40
## 726 657	Frogadier	Water		405	54	63	52
## 727 658	Greninja	Water	Dark	530	72	95	67
## 728 659	Bunnelby	Normal		237	38	36	38
## 729 660	Diggersby	Normal	Ground	423	85	56	77
## 730 661	Fletchling	Normal	Flying	278	45	50	43

##	731	662		Fletchinder	Fire	Flying	382	62	73	55	
##	732	663		Talonflame	Fire	Flying	499	78	81	71	
##	733	664		Scatterbug	Bug		200	38	35	40	
##	734	665		Spewpa	Bug		213	45	22	60	
##	735	666		Vivillon	Bug	Flying	411	80	52	50	
##	736	667		Littleo	Fire	Normal	369	62	50	58	
##	737	668		Pyroar	Fire	Normal	507	86	68	72	
##	741	672		Skiddo	Grass		350	66	65	48	
##	742	673		Gogoat	Grass		531	123	100	62	
##	745	676		Furfrou	Normal		472	75	80	60	
##	746	677		Espurr	Psychic		355	62	48	54	
##	747	678		MeowsticMale	Psychic		466	74	48	76	
##	748	678		MeowsticFemale	Psychic		466	74	48	76	
##	763	692		Clauncher	Water		330	50	53	62	
##	764	693		Clawitzer	Water		500	71	73	88	
##	798	720		HoopaaHoopaa	Confined	Psychic	Ghost	600	80	110	60
##	799	720		HoopaaHoopaa	Unbound	Psychic	Dark	680	80	160	60
##	800	721		Volcanion	Fire	Water	600	80	110	120	
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## 519	125	95	83	4	False
## 521	116	56	95	4	False
## 522	60	65	95	4	False
## 526	135	75	90	4	False
## 527	65	115	80	4	False
## 528	65	115	110	4	False
## 538	75	130	95	4	True
## 539	105	105	80	4	True
## 540	125	70	115	4	True
## 542	150	120	100	4	True
## 543	130	106	77	4	True
## 544	80	110	100	4	True
## 547	75	130	85	4	False
## 548	80	80	80	4	False
## 549	100	100	100	4	False
## 551	100	100	100	4	True
## 552	120	75	127	4	True
## 553	120	120	120	4	True
## 554	100	100	100	5	True
## 555	45	55	63	5	False
## 556	60	75	83	5	False
## 557	75	95	113	5	False
## 558	45	45	45	5	False
## 559	70	55	55	5	False
## 560	100	65	65	5	False
## 561	63	45	45	5	False
## 562	83	60	60	5	False
## 563	108	70	70	5	False
## 564	35	39	42	5	False
## 565	60	69	77	5	False
## 566	25	45	55	5	False
## 567	35	65	60	5	False
## 568	45	90	80	5	False
## 571	53	48	64	5	False
## 572	98	63	101	5	False
## 573	53	48	64	5	False
## 574	98	63	101	5	False
## 575	53	48	64	5	False
## 576	98	63	101	5	False
## 577	67	55	24	5	False
## 578	107	95	29	5	False
## 579	36	30	43	5	False

## 580	50	42	65	5	False
## 581	65	55	93	5	False
## 587	55	43	72	5	False
## 588	77	55	114	5	False
## 591	60	86	50	5	False
## 592	80	126	50	5	False
## 596	50	40	64	5	False
## 597	65	55	69	5	False
## 598	85	75	74	5	False
## 601	40	60	42	5	False
## 602	50	80	42	5	False
## 603	70	80	92	5	False
## 604	30	39	57	5	False
## 605	40	79	47	5	False
## 606	55	69	112	5	False
## 607	37	50	66	5	False
## 608	77	75	116	5	False
## 609	70	50	30	5	False
## 610	110	75	90	5	False
## 611	80	55	98	5	False
## 615	15	45	50	5	False
## 616	30	55	95	5	False
## 617	140	105	55	5	False
## 618	106	67	60	5	False
## 619	35	35	55	5	False
## 620	65	75	45	5	False
## 623	103	80	97	5	False
## 626	53	45	22	5	False
## 627	83	65	32	5	False
## 634	40	40	75	5	False
## 635	65	60	115	5	False
## 636	55	65	45	5	False
## 637	75	85	55	5	False
## 638	95	110	65	5	False
## 639	105	50	20	5	False
## 640	125	60	30	5	False
## 641	125	85	30	5	False
## 642	44	50	55	5	False
## 643	87	63	98	5	False
## 647	40	50	75	5	False
## 648	60	70	95	5	False
## 650	40	45	60	5	False
## 651	60	105	20	5	False
## 652	55	55	15	5	False
## 653	85	80	30	5	False
## 654	65	85	40	5	False
## 655	85	105	60	5	False
## 656	40	45	65	5	False
## 657	57	50	65	5	False
## 658	97	60	108	5	False
## 659	24	86	10	5	False
## 660	54	116	20	5	False
## 667	85	55	30	5	False
## 668	125	95	40	5	False

```
## 678      40      65      25          5      False
## 679     100      60     145          5      False
## 688      40      95      55          5      False
## 689      37      50      60          5      False
## 690      57      75      80          5      False
## 693     105      66      65          5      False
## 694      48      48     109          5      False
## 698      50      55      60          5      False
## 699     135     105     100          5      False
## 702      90     129     108          5       True
## 714     129      90     108          5      False
## 715     129      90     108          5      False
## 716     128     128      90          5      False
## 717      77      77     128          5      False
## 718     120      95      99          5      False
## 719      48      45      38          6      False
## 720      56      58      57          6      False
## 721      74      75      64          6      False
## 722      62      60      60          6      False
## 723      90      70      73          6      False
## 724     114     100     104          6      False
## 725      62      44      71          6      False
## 726      83      56      97          6      False
## 727     103      71     122          6      False
## 728      32      36      57          6      False
## 729      50      77      78          6      False
## 730      40      38      62          6      False
## 731      56      52      84          6      False
## 732      74      69     126          6      False
## 733      27      25      35          6      False
## 734      27      30      29          6      False
## 735      90      50      89          6      False
## 736      73      54      72          6      False
## 737     109      66     106          6      False
## 741      62      57      52          6      False
## 742      97      81      68          6      False
## 745      65      90     102          6      False
## 746      63      60      68          6      False
## 747      83      81     104          6      False
## 748      83      81     104          6      False
## 763      58      63      44          6      False
## 764     120      89      59          6      False
## 798     150     130      70          6       True
## 799     170     130      80          6       True
## 800     130      90      70          6       True
```

```
names <- c('type_1', 'legendary', 'generation')
pokemon_filter[,names] <- lapply(pokemon_filter[,names] , factor)
str(pokemon_filter)
```

```
## 'data.frame':   458 obs. of  13 variables:
## $ x          : int  1 2 3 3 4 5 6 6 6 7 ...
## $ name       : chr  "Bulbasaur" "Ivysaur" "Venusaur" "VenusaurMega Venusaur" ...
## $ type_1     : Factor w/ 6 levels "Bug","Fire","Grass",...: 3 3 3 3 2 2 2 2 2 6 ...
```

```
## $ type_2      : chr  "Poison" "Poison" "Poison" "Poison" ...
## $ total       : int   318 405 525 625 309 405 534 634 634 314 ...
## $ hp          : int   45 60 80 80 39 58 78 78 78 44 ...
## $ attack      : int   49 62 82 100 52 64 84 130 104 48 ...
## $ defense     : int   49 63 83 123 43 58 78 111 78 65 ...
## $ sp_atk      : int   65 80 100 122 60 80 109 130 159 50 ...
## $ sp_def      : int   65 80 100 120 50 65 85 85 115 64 ...
## $ speed       : int   45 60 80 80 65 80 100 100 100 43 ...
## $ generation: Factor w/ 6 levels "1","2","3","4",...: 1 1 1 1 1 1 1 1 1 1 ...
## $ legendary   : Factor w/ 2 levels "False","True": 1 1 1 1 1 1 1 1 1 1 ...
```

```
#as_factor(pokemon_filter$type_1)
#as_factor(pokemon_filter$legendary)
```

Exercise 3

Perform an initial split of the data. Stratify by the outcome variable. You can choose a proportion to use. Verify that your training and test sets have the desired number of observations.

Next, use v-fold cross-validation on the training set. Use 5 folds. Stratify the folds by ‘type_1’ as well. Why might stratifying the folds be useful?

If we stratify our folds, then the folds in our training set are selected so that the mean response value is approximately equal in all the folds. Therefore, this is useful since each class is equally represented across each train fold.

```
set.seed(3435)
pokemon_split <- initial_split(pokemon_filter, strata = "type_1")

pokemon_train <- training(pokemon_split)
pokemon_test  <- testing(pokemon_split)

pokemon_fold <- vfold_cv(pokemon_train, v = 5, strata = "type_1")
pokemon_fold
```

```
## # 5-fold cross-validation using stratification
## # A tibble: 5 x 2
##   splits          id
##   <list>         <chr>
## 1 <split [270/71]> Fold1
## 2 <split [271/70]> Fold2
## 3 <split [273/68]> Fold3
## 4 <split [274/67]> Fold4
## 5 <split [276/65]> Fold5
```

Exercise 4

Set up a recipe to predict type_1 with legendary, generation, sp_atk, attack, speed, defense, hp, and sp_def.

- Dummy-code legendary and generation;
- Center and scale all predictors.

```
#change into factors
pokemon_recipe <- recipe(type_1 ~ legendary + generation + sp_atk + attack + speed + defense + hp + sp_c
  step_dummy(legendary, generation) %>%
  step_novel(all_nominal_predictors()) %>%
  step_dummy(all_nominal_predictors()) %>%
  step_zv(all_predictors()) %>%
  step_normalize(all_numeric()) %>%
  step_center(all_numeric()) %>%
  step_scale(all_numeric())
```

Exercise 5

We'll be fitting and tuning an elastic net, tuning `penalty` and `mixture` (use `multinom_reg` with the `glmnet` engine).

Set up this model and workflow. Create a regular grid for `penalty` and `mixture` with 10 levels each; `mixture` should range from 0 to 1. For this assignment, we'll let `penalty` range from -5 to 5 (it's log-scaled).

How many total models will you be fitting when you fit these models to your folded data?

There will be 10 total models when we fit them into the folded data.

```
library("glmnet")

pokemon_spec <- parsnip::multinom_reg(mixture = 1, penalty = tune()) %>%
  set_mode("classification") %>%
  set_engine("glmnet")

pokemon_workflow <- workflow() %>%
  add_recipe(pokemon_recipe) %>%
  add_model(pokemon_spec)

penalty_grid <- grid_regular(penalty(range = c(-5, 5)), levels = 10)
penalty_grid
```

```
## # A tibble: 10 x 1
##       penalty
##       <dbl>
## 1      0.00001
## 2      0.000129
## 3      0.00167
## 4      0.0215
## 5      0.278
## 6      3.59
## 7     46.4
## 8     599.
## 9    7743.
## 10 100000
```

Exercise 6

Fit the models to your folded data using `tune_grid()`.

Use `autoplot()` on the results. What do you notice? Do larger or smaller values of `penalty` and `mixture` produce better accuracy and ROC AUC?

Larger values of ‘`penalty`’ and ‘`mixture`’ produce better accuracy and ROC AUC. This is because as ‘`penalty`’ and ‘`mixture`’ get larger, the standard error for accuracy and ROC AUC reduces.

```
tune_res <- tune_grid(
  pokemon_workflow,
  resamples = pokemon_fold,
  grid = penalty_grid,
  control = control_grid(verbose = TRUE)
)
```

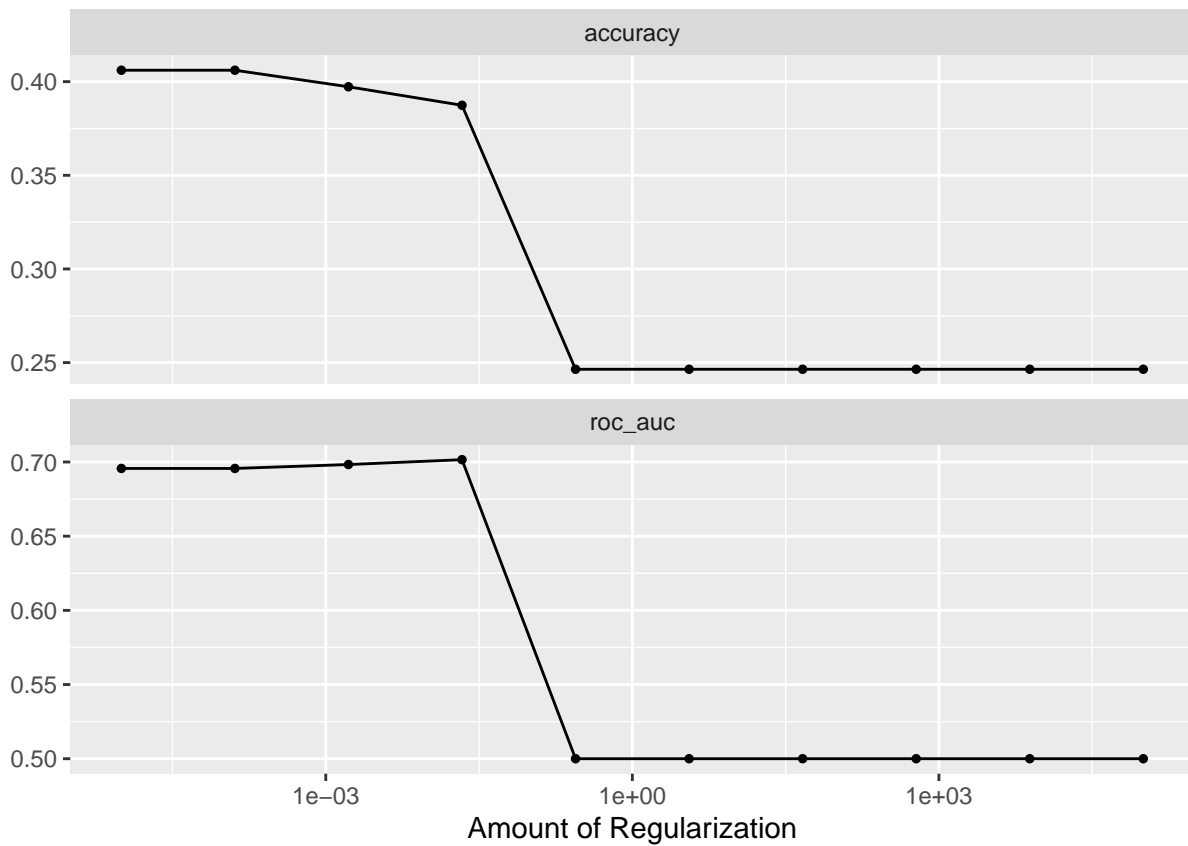
```
tune_res
```

```
## # Tuning results
## # 5-fold cross-validation using stratification
## # A tibble: 5 x 4
##   splits      id    .metrics      .notes
##   <list>      <chr> <list>      <list>
## 1 <split [270/71]> Fold1 <tibble [20 x 5]> <tibble [0 x 3]>
## 2 <split [271/70]> Fold2 <tibble [20 x 5]> <tibble [0 x 3]>
## 3 <split [273/68]> Fold3 <tibble [20 x 5]> <tibble [0 x 3]>
## 4 <split [274/67]> Fold4 <tibble [20 x 5]> <tibble [0 x 3]>
## 5 <split [276/65]> Fold5 <tibble [20 x 5]> <tibble [0 x 3]>
```

```
collect_metrics(tune_res)
```

```
## # A tibble: 20 x 7
##       penalty .metric .estimator  mean     n std_err .config
##       <dbl> <chr>   <chr>      <dbl> <int>  <dbl> <chr>
## 1  0.00001 accuracy multiclass 0.406     5 0.0306 Preprocessor1_Model01
## 2  0.00001 roc_auc   hand_till 0.696     5 0.0144 Preprocessor1_Model01
## 3  0.000129 accuracy multiclass 0.406     5 0.0306 Preprocessor1_Model02
## 4  0.000129 roc_auc   hand_till 0.696     5 0.0144 Preprocessor1_Model02
## 5  0.00167 accuracy multiclass 0.397     5 0.0350 Preprocessor1_Model03
## 6  0.00167 roc_auc   hand_till 0.698     5 0.0139 Preprocessor1_Model03
## 7  0.0215 accuracy multiclass 0.387     5 0.0202 Preprocessor1_Model04
## 8  0.0215 roc_auc   hand_till 0.702     5 0.0121 Preprocessor1_Model04
## 9  0.278 accuracy multiclass 0.246     5 0.00253 Preprocessor1_Model05
## 10 0.278 roc_auc   hand_till 0.5       5 0       Preprocessor1_Model05
## 11 3.59 accuracy multiclass 0.246     5 0.00253 Preprocessor1_Model06
## 12 3.59 roc_auc   hand_till 0.5       5 0       Preprocessor1_Model06
## 13 46.4 accuracy multiclass 0.246     5 0.00253 Preprocessor1_Model07
## 14 46.4 roc_auc   hand_till 0.5       5 0       Preprocessor1_Model07
## 15 599. accuracy multiclass 0.246     5 0.00253 Preprocessor1_Model08
## 16 599. roc_auc   hand_till 0.5       5 0       Preprocessor1_Model08
## 17 7743. accuracy multiclass 0.246     5 0.00253 Preprocessor1_Model09
## 18 7743. roc_auc   hand_till 0.5       5 0       Preprocessor1_Model09
## 19 100000 accuracy multiclass 0.246     5 0.00253 Preprocessor1_Model10
## 20 100000 roc_auc   hand_till 0.5       5 0       Preprocessor1_Model10
```

```
autoplot(tune_res)
```



Exercise 7

Use `select_best()` to choose the model that has the optimal `roc_auc`. Then use `finalize_workflow()`, `fit()`, and `augment()` to fit the model to the training set and evaluate its performance on the testing set.

```
library(dplyr)
library(tidyr)

best_penalty <- select_best(tune_res, metric = "roc_auc")
best_penalty

## # A tibble: 1 x 2
##   penalty .config
##   <dbl> <chr>
## 1  0.0215 Preprocessor1_Model104

pokemon_final <- finalize_workflow(pokemon_workflow, best_penalty)

pokemon_final_fit <- fit(pokemon_final, data = pokemon_train)
pokemon_final_fit
```

```

## == Workflow [trained] =====
## Preprocessor: Recipe
## Model: multinom_reg()
##
## -- Preprocessor -----
## 7 Recipe Steps
##
## * step_dummy()
## * step_novel()
## * step_dummy()
## * step_zv()
## * step_normalize()
## * step_center()
## * step_scale()
##
## -- Model -----
##
## Call:  glmnet::glmnet(x = maybe_matrix(x), y = y, family = "multinomial",      alpha = ~1)
##
##      Df  %Dev   Lambda
## 1    0  0.00 0.127700
## 2    1  0.48 0.116400
## 3    1  0.88 0.106000
## 4    2  1.57 0.096620
## 5    2  2.28 0.088030
## 6    2  2.86 0.080210
## 7    3  3.94 0.073090
## 8    3  4.88 0.066590
## 9    3  5.68 0.060680
## 10   3  6.46 0.055290
## 11   3  7.15 0.050380
## 12   4  7.80 0.045900
## 13   6  8.51 0.041820
## 14   7  9.30 0.038110
## 15   9 10.28 0.034720
## 16   9 11.21 0.031640
## 17   9 12.10 0.028830
## 18   9 12.91 0.026270
## 19  10 13.79 0.023930
## 20  11 14.63 0.021810
## 21  11 15.37 0.019870
## 22  11 16.00 0.018100
## 23  11 16.56 0.016500
## 24  11 17.05 0.015030
## 25  11 17.50 0.013700
## 26  11 17.90 0.012480
## 27  11 18.26 0.011370
## 28  11 18.57 0.010360
## 29  11 18.87 0.009440
## 30  12 19.13 0.008601
## 31  12 19.38 0.007837
## 32  12 19.61 0.007141
## 33  12 19.80 0.006506
## 34  12 19.97 0.005928

```



```
## 35 12 20.12 0.005402
## 36 12 20.25 0.004922
## 37 12 20.37 0.004485
## 38 12 20.48 0.004086
## 39 12 20.58 0.003723
## 40 12 20.65 0.003392
## 41 12 20.72 0.003091
## 42 12 20.78 0.002816
## 43 12 20.83 0.002566
## 44 12 20.87 0.002338
## 45 12 20.91 0.002131
## 46 12 20.94 0.001941
##
## ...
## and 23 more lines.
```

pokemon_test

##	x		name	type_1	type_2	total	hp	attack	defense
## 4	3	VenusaurMega	Venusaur	Grass	Poison	625	80	100	123
## 8	6	CharizardMega	Charizard X	Fire	Dragon	634	78	130	111
## 13	9	BlastoiseMega	Blastoise	Water		630	79	103	120
## 19	15		Beedrill	Bug	Poison	395	65	90	40
## 20	15	BeedrillMega	Beedrill	Bug	Poison	495	65	150	40
## 26	20		Raticate	Normal		413	55	81	60
## 44	38		Ninetales	Fire		505	73	76	75
## 46	40		Wigglytuff	Normal	Fairy	435	140	70	45
## 66	60		Poliwhag	Water		300	40	50	40
## 67	61		Poliwhirl	Water		385	65	65	65
## 80	73		Tentacruel	Water	Poison	515	80	70	65
## 85	78		Rapidash	Fire		500	65	100	70
## 92	84		Doduo	Normal	Flying	310	35	85	45
## 108	99		Kingler	Water		475	55	130	115
## 111	102		Exeggcute	Grass	Psychic	325	60	40	80
## 128	118		Goldeen	Water		320	45	67	60
## 142	130	GyaradosMega	Gyarados	Water	Dark	640	95	155	109
## 167	152		Chikorita	Grass		318	45	49	65
## 170	155		Cyndaquil	Fire		309	39	52	43
## 177	162		Furret	Normal		415	85	76	64
## 180	165		Ledyba	Bug	Flying	265	40	20	30
## 183	168		Ariados	Bug	Poison	390	70	90	70
## 185	170		Chinchou	Water	Electric	330	75	38	38
## 186	171		Lanturn	Water	Electric	460	125	58	58
## 198	182		Bellossom	Grass		490	75	80	95
## 199	183		Marill	Water	Fairy	250	70	20	50
## 206	190		Aipom	Normal		360	55	70	55
## 218	202		Wobbuffet	Psychic		405	190	33	58
## 228	211		Qwilfish	Water	Poison	430	65	95	75
## 232	214		Heracross	Bug	Fighting	500	80	125	75
## 242	223		Remoraid	Water		300	35	65	35
## 245	226		Mantine	Water	Flying	465	65	40	70
## 254	234		Stantler	Normal		465	73	95	62
## 260	240		Magby	Fire		365	45	75	37
## 262	242		Blissey	Normal		540	255	10	10

##	272	251	Celebi	Psychic	Grass	600	100	100	100
##	273	252	Treecko	Grass		310	40	45	35
##	274	253	Grovyle	Grass		405	50	65	45
##	282	259	Marshtomp	Water	Ground	405	70	85	70
##	287	263	Zigzagoon	Normal		240	38	30	41
##	292	268	Cascoon	Bug		205	50	35	55
##	293	269	Dustox	Bug	Poison	385	60	50	70
##	300	276	Tailow	Normal	Flying	270	40	55	30
##	303	279	Pelipper	Water	Flying	430	60	50	100
##	304	280	Ralts	Psychic	Fairy	198	28	25	25
##	306	282	Gardevoir	Psychic	Fairy	518	68	65	65
##	308	283	Surskit	Bug	Water	269	40	30	32
##	315	290	Nincada	Bug	Ground	266	31	45	90
##	317	292	Shedinja	Bug	Ghost	236	1	90	45
##	318	293	Whismur	Normal		240	64	51	23
##	320	295	Exploud	Normal		490	104	91	63
##	326	301	Delcatty	Normal		380	70	65	65
##	343	313	Volbeat	Bug		400	65	73	55
##	349	319	Sharpedo	Water	Dark	460	70	120	40
##	351	320	Wailmer	Water		400	130	70	35
##	352	321	Wailord	Water		500	170	90	45
##	353	322	Numel	Fire	Ground	305	60	60	40
##	357	325	Spoink	Psychic		330	60	25	35
##	358	326	Grumpig	Psychic		470	80	45	65
##	368	335	Zangoose	Normal		458	73	115	60
##	395	360	Wynaut	Psychic		260	95	23	48
##	402	366	Clamperl	Water		345	35	64	85
##	403	367	Huntail	Water		485	55	104	105
##	405	369	Relicanth	Water	Rock	485	100	90	130
##	423	382	KyogrePrimal Kyogre	Water		770	100	150	90
##	430	386	DeoxysAttack Forme	Psychic		600	50	180	20
##	432	386	DeoxysSpeed Forme	Psychic		600	50	95	90
##	435	389	Torterra	Grass	Ground	525	95	109	105
##	439	393	Piplup	Water		314	53	51	53
##	446	400	Bibarel	Normal	Water	410	79	85	60
##	447	401	Kricketot	Bug		194	37	25	41
##	458	412	Burmy	Bug		224	40	29	45
##	464	416	Vespiquen	Bug	Flying	474	70	80	102
##	466	418	Buizel	Water		330	55	65	35
##	477	428	LopunnyMega Lopunny	Normal	Fighting	580	65	136	94
##	506	455	Carnivine	Grass		454	74	100	72
##	510	459	Snover	Grass	Ice	334	60	62	50
##	511	460	Abomasnow	Grass	Ice	494	90	92	75
##	526	474	Porygon-Z	Normal		535	85	80	70
##	539	481	Mesprit	Psychic		580	80	105	105
##	542	484	Palkia	Water	Dragon	680	90	120	100
##	543	485	Heatran	Fire	Steel	600	91	90	106
##	551	492	ShayminLand Forme	Grass		600	100	100	100
##	555	495	Snivy	Grass		308	45	45	55
##	558	498	Tepig	Fire		308	65	63	45
##	565	505	Watchog	Normal		420	60	85	69
##	567	507	Herdier	Normal		370	65	80	65
##	572	512	Simisage	Grass		498	75	98	63
##	573	513	Pansear	Fire		316	50	53	48

##	578	518	Musharna	Psychic		487	116	55	85
##	581	521	Unfezant	Normal	Flying	488	80	115	80
##	592	531	AudinoMega Audino	Normal	Fairy	545	103	60	126
##	601	540	Sewaddle	Bug	Grass	310	45	53	70
##	608	547	Whimsicott	Grass	Fairy	480	60	67	85
##	609	548	Petilil	Grass		280	45	35	50
##	610	549	Lilligant	Grass		480	70	60	75
##	616	555	DarmanitanStandard Mode	Fire		480	105	140	55
##	618	556	Maractus	Grass		461	75	86	67
##	627	565	Carracosta	Water	Rock	495	74	108	133
##	637	575	Gothorita	Psychic		390	60	45	70
##	638	576	Gothitelle	Psychic		490	70	55	95
##	641	579	Reuniclus	Psychic		490	110	65	75
##	648	586	Sawsbuck	Normal	Grass	475	80	100	70
##	654	592	Frillish	Water	Ghost	335	55	40	50
##	655	593	Jellicent	Water	Ghost	480	100	60	70
##	678	616	Shelmet	Bug		305	50	40	85
##	689	627	Rufflet	Normal	Flying	350	70	83	50
##	693	631	Heatmor	Fire		484	85	97	66
##	699	637	Volcarona	Bug	Fire	550	85	60	65
##	716	648	MeloettaAria Forme	Normal	Psychic	600	100	77	77
##	719	650	Chespin	Grass		313	56	61	65
##	728	659	Bunnelby	Normal		237	38	36	38
##	734	665	Spewpa	Bug		213	45	22	60
##	736	667	Litleo	Fire	Normal	369	62	50	58
##	737	668	Pyroar	Fire	Normal	507	86	68	72
##	745	676	Furfrou	Normal		472	75	80	60
##	747	678	MeowsticMale	Psychic		466	74	48	76
##			sp_atk	sp_def	speed	generation	legendary		
##	4		122	120	80	1	False		
##	8		130	85	100	1	False		
##	13		135	115	78	1	False		
##	19		45	80	75	1	False		
##	20		15	80	145	1	False		
##	26		50	70	97	1	False		
##	44		81	100	100	1	False		
##	46		85	50	45	1	False		
##	66		40	40	90	1	False		
##	67		50	50	90	1	False		
##	80		80	120	100	1	False		
##	85		80	80	105	1	False		
##	92		35	35	75	1	False		
##	108		50	50	75	1	False		
##	111		60	45	40	1	False		
##	128		35	50	63	1	False		
##	142		70	130	81	1	False		
##	167		49	65	45	2	False		
##	170		60	50	65	2	False		
##	177		45	55	90	2	False		
##	180		40	80	55	2	False		
##	183		60	60	40	2	False		
##	185		56	56	67	2	False		
##	186		76	76	67	2	False		
##	198		90	100	50	2	False		

## 199	20	50	40	2	False
## 206	40	55	85	2	False
## 218	33	58	33	2	False
## 228	55	55	85	2	False
## 232	40	95	85	2	False
## 242	65	35	65	2	False
## 245	80	140	70	2	False
## 254	85	65	85	2	False
## 260	70	55	83	2	False
## 262	75	135	55	2	False
## 272	100	100	100	2	False
## 273	65	55	70	3	False
## 274	85	65	95	3	False
## 282	60	70	50	3	False
## 287	30	41	60	3	False
## 292	25	25	15	3	False
## 293	50	90	65	3	False
## 300	30	30	85	3	False
## 303	85	70	65	3	False
## 304	45	35	40	3	False
## 306	125	115	80	3	False
## 308	50	52	65	3	False
## 315	30	30	40	3	False
## 317	30	30	40	3	False
## 318	51	23	28	3	False
## 320	91	73	68	3	False
## 326	55	55	70	3	False
## 343	47	75	85	3	False
## 349	95	40	95	3	False
## 351	70	35	60	3	False
## 352	90	45	60	3	False
## 353	65	45	35	3	False
## 357	70	80	60	3	False
## 358	90	110	80	3	False
## 368	60	60	90	3	False
## 395	23	48	23	3	False
## 402	74	55	32	3	False
## 403	94	75	52	3	False
## 405	45	65	55	3	False
## 423	180	160	90	3	True
## 430	180	20	150	3	True
## 432	95	90	180	3	True
## 435	75	85	56	4	False
## 439	61	56	40	4	False
## 446	55	60	71	4	False
## 447	25	41	25	4	False
## 458	29	45	36	4	False
## 464	80	102	40	4	False
## 466	60	30	85	4	False
## 477	54	96	135	4	False
## 506	90	72	46	4	False
## 510	62	60	40	4	False
## 511	92	85	60	4	False
## 526	135	75	90	4	False

```
## 539    105    105    80         4      True
## 542    150    120   100         4      True
## 543    130    106    77         4      True
## 551    100    100   100         4      True
## 555     45     55    63         5     False
## 558     45     45    45         5     False
## 565     60     69    77         5     False
## 567     35     65    60         5     False
## 572     98     63   101         5     False
## 573     53     48    64         5     False
## 578    107     95    29         5     False
## 581     65     55    93         5     False
## 592     80    126    50         5     False
## 601     40     60    42         5     False
## 608     77     75   116         5     False
## 609     70     50    30         5     False
## 610    110     75    90         5     False
## 616     30     55    95         5     False
## 618    106     67    60         5     False
## 627     83     65    32         5     False
## 637     75     85    55         5     False
## 638     95    110    65         5     False
## 641    125     85    30         5     False
## 648     60     70    95         5     False
## 654     65     85    40         5     False
## 655     85    105    60         5     False
## 678     40     65    25         5     False
## 689     37     50    60         5     False
## 693    105     66    65         5     False
## 699    135    105   100         5     False
## 716    128    128    90         5     False
## 719     48     45    38         6     False
## 728     32     36    57         6     False
## 734     27     30    29         6     False
## 736     73     54    72         6     False
## 737    109     66   106         6     False
## 745     65     90   102         6     False
## 747     83     81   104         6     False
```

```
pokemon_predict <- augment(pokemon_final_fit, new_data = pokemon_test)
```

```
pokemon_predict
```

```
## # A tibble: 117 x 20
```

```
##      x name      type_1 type_2 total    hp attack defense sp_atk sp_def speed
##    <int> <chr>      <fct> <chr> <int> <int> <int>  <int>  <int>  <int>
##  1     3 VenusaurM~ Grass "Pois~  625   80   100   123   122   120   80
##  2     6 Charizard~ Fire  "Drag~  634   78   130   111   130    85  100
##  3     9 Blastoise~ Water ""      630   79   103   120   135   115   78
##  4    15 Beedrill  Bug   "Pois~  395   65    90    40    45    80   75
##  5    15 BeedrillM~ Bug   "Pois~  495   65   150    40    15    80  145
##  6    20 Raticate  Normal ""      413   55    81    60    50    70   97
##  7    38 Ninetales Fire  ""      505   73    76    75    81   100  100
##  8    40 Wigglytuff Normal "Fair~  435  140    70    45    85    50   45
```

```
## 9      60 Poliwhag    Water ""      300    40    50    40    40    40    90
## 10     61 Poliwhirl  Water ""      385    65    65    65    50    50    90
## # ... with 107 more rows, and 9 more variables: generation <fct>,
## #   legendary <fct>, .pred_class <fct>, .pred_Bug <dbl>, .pred_Fire <dbl>,
## #   .pred_Grass <dbl>, .pred_Normal <dbl>, .pred_Psychic <dbl>,
## #   .pred_Water <dbl>
```

Exercise 8

Calculate the overall ROC AUC on the testing set.

Then create plots of the different ROC curves, one per level of the outcome. Also make a heat map of the confusion matrix.

What do you notice? How did your model do? Which Pokemon types is the model best at predicting, and which is it worst at? Do you have any ideas why this might be?

The overall ROC AUC on the testing set is 0.680233. I think the Pokemon “Water” was the best at predicting because the predictions with all the other predictors are fairly high. Additionally, “Normal” seems to also look pretty good with the predictions with other variables. However, “Fire” and “Grass” seem to be a bad predictor for our model because the values of our confusion matrix are almost all zeroes. Therefore, Pokemon types Water and Normal are good at predicting whereas Fire and Grass are not good predictors.

```
test_roc_auc <- roc_auc(data = pokemon_predict, truth = type_1, estimator = "macro_weighted", estimate = "auc")
test_roc_auc $ .estimate
```

```
## [1] 0.6802553
```

```
augment(pokemon_final_fit, new_data = pokemon_train) %>%
  conf_mat(truth = type_1, estimate = .pred_class) %>%
  autoplot(type = "heatmap")
```

Prediction	Bug -	11	0	4	0	0	3
	Fire -	0	1	0	0	0	1
	Grass -	0	0	0	0	0	0
	Normal -	20	5	9	59	5	21
	Psychic -	0	5	3	1	20	2
	Water -	20	28	36	13	17	57
		Bug	Fire	Grass	Normal	Psychic	Water
		Truth					